3.0
OVERALL PROJECT OBJECTIVES

As stated in Section VI, paragraph 30 of the AOC, the overall objective of the RI/FS is "to assess Site conditions and evaluate alternatives to prevent and/or mitigate any actual and/or potential threat of harm to human health or welfare or the environment caused by release and threatened release of hazardous substances from the site." This section of the IWP discusses the overall project objectives associated with the RI portion of the project. The FS objectives are presented in the FSWP.

In order to fulfill the objectives of the RI portion of the RI/FS, three tasks are identified in the SOW; these tasks are Sediment Characterization, Human and Ecological Risk Assessment, and Sediment Mobility Modeling. The objectives for these tasks are presented below.

The goal of the work to be performed for the Sediment Characterization task for the Passaic River Study Area as stated in SOW Section A.1 is to, "Determine the horizontal and vertical distribution and concentration of PCDD's, PCDF's, PCB's, PAH's, pesticides and metals from Passaic River sediments from the Passaic River Study Area...". In order to identify the distribution and concentrations of chemicals within the sediments, samples will be collected at several depths within the sediments and analyzed for the chemicals listed above. In accordance with provisions stated in the SOW, sediment samples will be collected and characterized as a function of the date of sediment deposition.

The goal of the work to be performed for the Human and Ecological Risk Assessment for the Passaic River Study Area as stated in SOW Section A.2 is to, "Determine the primary human and ecological receptors (endpoints) of PCDDs, PCDFs, PCBs, PAHs, pesticides, and metals contaminated sediments in the Passaic River Study Area...". To achieve this goal, contaminants of potential concern will be identified, ecotoxicological endpoints and ecological effects associated with contaminant exposure to key organisms will be identified, and potential uptake of the contaminants of potential concern from the sediments and water through the food web by key organisms and by humans through consumption of fish and invertebrates will be evaluated.

The goal of the work to be performed for the Sediment Mobility Task as stated in the SOW Section A.3. is to "Determine contaminated sediment transport within the boundaries of the Passaic River Study Area...". This task will be implemented by using the USACE model STUDH. The STUDH modeling will include runs simulating past, present, and future migratory pathways and will include simulations using normal and stressed conditions (e.g., storm events including 100 year flood, etc.).

4.0
GRAPHICAL REPRESENTATION OF DATA

4.1 INTRODUCTION

In accordance with provisions presented in Paragraph 3.a.i.(3) of the Statement of Work, an "acceptable graphic representation (GIS or CAD format) of the Passaic River Study Area which includes all relevant data" will be prepared. This representation will facilitate EPA's selection of the location of ten additional sediment cores. Relevant data are defined as the location of past and present outfalls, areas of sediment deposition, location of all previous sampling locations and data associated with the locations, and contoured contaminant concentration gradients within the Passaic River Study Area.

This section will describe the relevant data sets to be used in compiling the graphic representations as well as the materials to be delivered to EPA in this graphic representation of data.

4.2 RELEVANT DATA

4.2.1 Outfalls

Outfalls are divided into two types, known present and known past. Known present outfalls are presently in use for process water discharge, cooling water discharge, stormwater discharge, and combined sewer discharge (i.e., combined sewer outfalls CSOs). Known past outfalls are 1) outfalls that served the same purposes as stated above but are no longer in use, and 2) outfalls that are only identifiable from historic records.

Present outfalls for which the location is only approximately known will be field-located to obtain co-ordinates to be input into the CAD or GIS system to enable graphic representation. Outfalls may be submerged and not readily observable in the field. Existing National Pollutant Discharge Elimination System (NPDES) permits will be reviewed so that outfalls presently in use are identified for inclusion in the graphic representation.

Historical information from known past outfalls will be digitized from available hard copy maps, location descriptions, or interpreted aerial photography. Once digitized the information will be entered into the CAD or GIS system so that hard copy displays can be generated.

4.2.2 Areas of Sediment Deposition

Areas of sediment deposition will be identified by using historic bathymetry data collected by USACE. From these bathymetric data, a sediment isopach (thickness) map will be generated representing the change in elevation between the sediment elevations in the bathymetric survey data. For most of the Site, bathymetric data collected in 1949 and in 1989 will be used in generating the isopach map. Since 1949 data do not exist in the Point No Point Reach, and since the Point No Point Reach has undergone significant dredging since 1940, the bathymetric surveys from 1983 (post-dredging) and 1989 will be used to generate the isopach map for this particular reach. Isopach surfaces will be calculated only where bathymetry data exist (i.e., only where recent and earlier bathymetry surface data overlap).

The isopach map generated for the Study Area will take into consideration the evaluation of errors and uncertainty performed in association with the Bathymetry Data Usability Section (See Section 8.0 of the IWP).

4.2.3 Previous Sampling Locations and Data

The previous sampling locations and data used in the graphic representations will be compiled from the following sampling events:

- EPA Region II FIT Team data from 1984
- 80/120 Lister Avenue Site Evaluation Data, originally reported to New Jersey Department of Environmental Protection (NJDEP) in 1985
- Passaic River Sediment Study Data presented to NJDEP in 1985 and revised version resubmitted to NJDEP as "Data Validation Final Report" in 1991
- 1990 Surficial Sample analyses performed on behalf of OCC.
- 1991 through 1993 sediment core analyses performed on behalf of OCC.

All of the above-described data and locations have been previously transmitted to EPA in the form of data books.

In addition, data provided by EPA (letter of transmittal from Mr. Lance Richman of EPA to Mr. Richard McNutt of Maxus, dated Dec. 22, 1993) presents analytical results for 2,3,7,8-TCDD analyses of surficial sediments and will be compiled for use in the graphic representations.

The following analytes will be used in the graphical representation of data: 2,3,7,8-TCDD; total PCDDs; 2,3,7,8-TCDF, total TCDF; cadmium; copper; mercury; lead; the sum of DDT, DDE, and DDD; the sum of PAHs; TOC; grain size; and total PCBs.

Data that have not been evaluated using EPA Region II QA/QC protocols will be flagged indicating that they have not been evaluated using these protocols.

4.2.4 Contoured Contaminant Concentrations

Contour maps of selected analytes from sediment samples will be hand generated where sufficient data exist. Data sufficiency will be determined based on the number and proximity of nearby cores. Based on conversations with EPA and NJDEP, it was agreed that sufficient data may not exist to support contouring. Additionally, a review of chemical data consistency in a given location will be performed to evaluate the feasibility of contouring.

4.3 DELIVERABLES

A Graphic Data Representation report will be delivered to EPA in accordance with the schedule contained in Section 10.0 of this IWP. This report will include proposed locations for the ten cores specified to be collected in Section B.3.a.i.(3) of the SOW. This report will also include the following hard copy graphic representations.

<u>Outfalls</u>

Plan view "hard-copies" will be generated showing the location of outfalls identified from the Global Positioning Systems (GPS) surveying, the NPDES permit review and historic information review. The outfalls will be shown for each river reach and will be identified as known present or known past outfalls.

Areas of Sediment Deposition

Isopach maps will be plan view, showing areas of net deposition, net sediment removal, and areas that cannot be delineated due to the uncertainty associated with collecting, digitizing and presenting historic bathymetric data. The Isopach maps will be prepared for each river reach. Structures that affect the hydrodynamic regime (e.g., bridges and CSOs) will also be shown.

Previous Sampling Locations and Data

Data collected from previous sampling events will be grouped into two time intervals, those collected from 1984-1989 and those collected from 1990 to present. Surficial samples will be presented separately from core samples. Figures representing concentrations of 2,3,7,8-TCDD; total PCDDs; 2,3,7,8-TCDF and total TCDF; cadmium; copper; mercury; lead; the sum of DDD, DDE and DDT; the sum of PAHs; TOC; grain size; and total PCBs will be prepared. The party responsible for each data set will be identified.

Maps of the river reaches in the Passaic River Study Area will show sampling locations and associated concentrations of the analytes of interest. Locations of core samples will be presented with an attached box to show each concentration at depth.

Contoured Contaminant Concentrations

In accordance with agreement reached in the March 22, 1994 conference call between representatives of EPA, NJDEP and OCC, hand-contoured contaminant concentrations (if sufficient data are available) from sediment samples will be presented in plan view for the reaches within the Passaic River Study Area.

5.0 CHARACTERIZATION OF THE SPATIAL DISTRIBUTION AND CONCENTRATION OF CHEMICALS IN SEDIMENTS

5.1 SEDIMENT CHARACTERIZATION TASK OBJECTIVES

The goal of the work to be performed in the Passaic River Study Area as stated in the AOC is to "Determine the horizontal and vertical distribution and concentration of PCDDs, PCDFs, PCBs, PAHs, pesticides, and metals from Passaic River sediments from the Passaic River Study Area...". In order to identify the distribution and concentrations of chemicals within the sediments, samples will be collected at several depths within the sediments. In accordance with provisions stated in the SOW, sediment samples will be collected and analyzed that are considered to be representative of the time-stratigraphic intervals specified in the SOW Section B.3.a.i.

Section B.3.a.i of the SOW describes the implementation of the Work to characterize the spatial distribution and concentration of contaminants in the Passaic River Study Area. This section specifies the location of sediment cores to be collected and the time-stratigraphic intervals within cores from which homogenized samples for chemical analysis will be taken. Section B.3.a.i.(5) of the SOW specifies that the samples collected from the cores will be homogenates of sediment throughout the decade intervals starting with 1940-50 decade through the 1980-1990 decade and that a sample from each core at the sediment surface will be collected to represent the biologically active zone (BAZ). This section of the SOW also states "EPA has also determined that a separate sediment sample from each core will be taken consisting of a homogenate sample from the time-stratigraphic period of 1955-65." Therefore, as described in detail below in Section 5.2, this IWP presents the procedures by which samples will be obtained for chemical characterization that are considered to be representative of the sediments deposited during 1940-50, 1950-60, 1960-70, 1970-80, 1980- bottom of the BAZ (to the extent that sediments remain for these time intervals), a sample from the BAZ itself, and a sample from the time interval 1955-65.

To identify chemical concentrations related to date of deposition, historic dredging information and bathymetry data collected by USACE have been used to identify historic sediment surfaces within the river. These data have been used to identify sediment surfaces considered to be representative of 1950, 1955, 1960, 1965, 1970, and 1980. Additional bathymetry data to be collected at the time of sample collection will be required to assess the depths associated with the more recent sediments. Based on these surfaces, samples will be obtained from time stratigraphic intervals considered representative of the sediments deposited during 1940-50, 1950-60, 1960-70, 1970-80, 1980-bottom of the BAZ (to the extent that sediments remain in these time intervals), a sample from the BAZ itself, and a sample from the time interval 1955-65. Core location will have approximate northing and easting coordinates and total depth recorded at the time of coring. The analytical data from these samples will be used to characterize contaminant distribution in the Passaic River Study Area for use in the risk assessment, feasibility study, and remedy selection process.

5.2 DETERMINATION OF CORE BORING LOCATIONS AND SAMPLING DEPTH INTERVALS

The Passaic River Study Area is a section (including intertidal shorelines) of the Passaic River from the abandoned ConRail railroad bridge upriver from the red channel junction marker at the confluence of the Hackensack and Passaic Rivers to a transect six miles (31,680 feet) upriver of this bridge.

5.2.1 1200-Foot Transect Location Selection

Section B.3.a.i.(1) of the SOW specifies that coring be done along transects spaced 1200 feet apart (26 transects) with three sediment core borings per transect for a total of 78 sediment cores. For this investigation, the abandoned ConRail railroad bridge was given the station designation 0+00, and all project transect locations were measured and numbered from this station location.

Initially, all transect locations were placed at 1200-foot spacings starting 600 feet upriver of the abandoned ConRail railroad bridge (Table 5-1) and plotted on the base map. However, numerous highway, road, and railroad bridges cross the river that are likely to have altered the natural depositional and erosional characteristics of the river. Seven of the 26 transect locations (transects 5, 6, 7, 19, 21, 22, and 23) were adjusted to avoid existing or abandoned (removed) bridges, or to keep the distances between transects consistent. Evaluation of the bathymetric data and coverage has indicated that the uncertainty in dating of these sediments decreases greatly in proximity to such bridges. Therefore, revising these positions will allow a better characterization of the sediments as a function of date of deposition.

Five transect locations were adjusted to avoid influences from bridges.

- Transect 7 (project station designation 82+00) was moved 400 feet upstream of its original location, which was between the New Jersey Turnpike and ConRail railroad bridges.

- Transect 19 (project station designation 223+00) was moved 100 feet upstream of its original location, which was 50 feet downstream of the abandoned Center Street bridge.

- Transect 21 (project station designation 242+00) was moved 400 feet downstream of its original location, which was between the William Stickel Memorial and ConRail railroad bridges.

- Transect 22 (project station designation 254+00) was moved 400 feet downstream of its original location, which was immediately downstream of the Clay Street bridge.

- Transect 23 (project station designation 268+00) was moved 200 feet downstream of its original location, which was 150 feet downstream of the abandoned ConRail railroad bridge (formerly the Erie-Lackawanna railroad bridge).

Due to the large adjustment necessary at transect 7 (i.e., 400 feet), transects 5 and 6 were adjusted in order to maintain a distance between transects as close to the project target of 1200 feet as practical. The location of transect 5 (project station designation 55+00) was moved 100 feet upstream of its original location. The location of transect 6 (project station designation 68+00) was moved 200 feet upstream of its original location. The distances between transect pairs after location adjustments ranged from 800 to 1400 feet (Table 5-1) with most intervals (16) remaining at 1200 feet. A summary of the 1200-foot transect location selections and adjustments is shown in Table 5-1.

5.2.2 Left, Middle, and Right Channel Bed Sediment Core Boring Location Selection

In accordance with the SOW Section B.3.a.i.(1), three core locations per transect were to be located in the following manner: 1) one in the left channel bed; 2) one in the middle section (thalweg); and 3) one in the right channel bed.

The criteria used to select the core locations are; stream morphology (based on historic bathymetric survey data); bathymetric survey coverage; bathymetric survey uncertainty; and the potential for identification of the required time-stratigraphic intervals. The location of the transects and the core sampling locations are presented for each reach in Figures 5-1 through 5-5. In general, the left and right channel bed sediment core boring locations were generally placed within the USACE Federal Project Limits of the Passaic River dredge channel. The bottom six transects have right and left channel bed locations outside of the dredge channel. These sampling locations were placed within the project limits since this is the area on the river for which the highest sedimentation rates for the period of interest are expected. In addition, sediment cores collected during the 1991-1993 field efforts (see Section 4.2.3) concentrated on near shore areas as indicated on Figures 5-1 through 5-5. The sediment core boring location information (i.e., transect number, sediment core boring location number, and New Jersey State Plane coordinates) is summarized in Table 3-1 of the FSP. Plan view locations of the three sediment core borings for each transect, along with the most recent bathymetric survey data line in the vicinity of that transect, are shown in Figures 5-6 through 5-31, respectively. The bathymetric data provide information on the position of the thalweg and right and left channel beds.

5.2.3 Chemical Sample Depth Interval Selection

The intent of the sediment core boring and sample collection phase of this investigation is to chemically characterize the sediments to the maximum time-stratigraphic depth determined by historical radio-geochemistry or bathymetric data which corresponds to the year 1940. Sediment samples collected from each chemical characterization core will be homogenates of sediment throughout each decade interval starting with the 1940-1950 decade through to the 1980-1990 decade (for a maximum of five sediment samples). The 1980-1990 sample interval will include sediments up to the bottom of the BAZ so as to not to leave sediment between 1990 and the bottom of the BAZ uncharacterized.

One sample will also be collected from each chemical characterization core at the river sediment surface (to a depth of 0.5 feet) representing the BAZ. In addition, the SOW states that a separate sediment sample shall be taken from each core as a homogenate sample representing the time-stratigraphic interval from 1955-1965.

In areas of scour, low sedimentation, or where existing radio-geochemistry dating, bathymetry, and other data are not sufficient to delineate time stratigraphic intervals, sediment cores will be taken to a depth of approximately 5 feet below the sediment surface. One sediment sample from the BAZ and five equally spaced homogenated sediment samples generally to a total depth of 5.5 feet will be collected and analyzed (Section 5.2.3.3).

Based on an evaluation process described in Section 8.0 of this IWP, six bathymetric surveys were selected to delineate the time-stratigraphic sampling intervals. These six bathymetric surveys (1949 pre-dredge, 1949 post-dredge, 1966, 1976, 1986, and 1989) were used to evaluate whether an adequate time-stratigraphic sampling interval scheme is present. Based on the requirements of the SOW Section B.3.a.i.(2),.(5), and .(6), four different chemical sample interval selection schemes (complete time-stratigraphic, partial time-stratigraphic, five equally spaced, and five one-foot) were used to assign sampling intervals reaching the maximum time-stratigraphic depth interval corresponding to the year 1940 for the 78 sediment core boring locations. For most cores, the 1940 sediment depth horizon was estimated by taking the average sedimentation rate from 1949 to 1989 and extrapolating from the 1949 post dredging bathymetric survey surface to the 1940 surface. The exceptions to this are represented by 12 cores for which there was no associated bathymetry. Each sampling scheme, the rationale behind the sampling scheme, along with a list of sediment core boring locations for each scheme, are discussed in detail below. A summary of the planned sampling intervals for each of the 78 sediment core borings is listed in Table 3-3 of the FSP.

5.2.3.1 <u>Complete Time-Stratigraphic Sampling Interval Selection Scheme</u>

The complete time-stratigraphic sampling interval selection scheme was used for sediment core boring locations where the following conditions exist:

- sufficient usable bathymetric data existed,
- no post-1949 dredging has taken place,
- moderate to high sedimentation has occurred since 1949, and
- a minimum of 4 inches of sample per decade sample interval was interpreted to be present.

This sampling scheme utilized the data from the six bathymetric surveys to select the required sampling intervals. Sampling interval boundaries for 1940, 1950, 1955, 1960, 1965, 1970, and 1980 were obtained from interpolation between sediment surfaces delineated by the six bathymetric surveys. The BAZ lower boundary is 0.5 feet below the present sediment surface. The thickness of the 1980-BAZ sampling interval will be determined using sediment depth measurements taken at the time of coring. The complete time-stratigraphic sampling interval selection scheme (designated "CT" in Table 3-3 of the FSP) was used for the following 30 sediment core boring locations:

Transect Number	Project Station Designation	Sediment Core Boring Number	River Reach
7	82 + 10	219	Harrison
8	89 + 90	222	Harrison
8	89 + 90	223	Harrison
9	102 + 00	225	Harrison
9	102 + 00	226	Harrison
10	114 + 00	228	Harrison
10	114 + 00	230	Harrison

Transect Number	Project Station Designation	Sediment Core Boring Number	River Reach
11	126 + 00	231	Harrison
12	138 + 00	234	Harrison
12	138 + 00	235	Harrison
12	138 + 00	236	Harrison
13	150 + 00	239	Harrison
14	162 + 00	241	Harrison
14	162 + 00	242	Harrison
15	174 + 00	245	Harrison
16	186 + 00	248	Newark
17	198 + 00	249	Newark
17	198 + 00	251	Newark
18	210 + 00	252	Newark
18	210 + 00	253	Newark
19	222 + 90	256	Newark
19	222 + 90	257	Newark
20	234 + 00	259	Newark
23	267 + 70	269	Kearny
24	282 + 70	270	Kearny
24	282 + 70	271	Kearny
24	282 + 70	272	Kearny
25	294 + 00	274	Kearny
25	294 + 00	275	Kearny
26	306 + 00	276	Kearny

5.2.3.2 <u>Partial Time-Stratigraphic Sampling Interval Selection Scheme</u>

The partial time-stratigraphic sampling scheme was used for sediment core boring locations within the lower reach of the Passaic River where numerous dredging events have taken place since the late 1800s including several since 1940. The Federal Project dredging depth limit for this reach of the river has been approximately 30 feet below mean low water (MLW), and allows for two feet of overdredging. Since the last dredging event took place in 1983, depth to sediment in 1983 was considered to be the depth to the dredging that occurred that year. Sediments within the Federal Project Limit at depths less than 30 feet were attributed to post 1983 sedimentation. Therefore, the BAZ and the 1983 to the bottom of the BAZ sampling intervals can be delineated with a fairly high degree of confidence. The prior decade intervals, however, cannot be delineated due to the numerous dredging events during which sediments from these earlier decades were probably removed by dredging. In order to confirm that sediments below the Federal Project Limit of 30 feet (MLW) represent pre-1940s sedimentation, the core boring will extend 4 feet below this surface and sediment age confirmed through radiochemical dating. This 4 feet of core will be split into two, 2-foot long homogenated samples for chemical characterization. The upper of the two, 2-foot long samples will account for the two-foot overdredging allowance, while the lower of the two, 2-foot samples should account for sediments dating back to before 1940. The partial time-stratigraphic sampling interval selection scheme (designated "PT" in Table 3-3 of the FSP) was used for the following 6 sediment core boring locations:

Transect Number	Project Station Designation	Sediment Core Boring Number	River Reach
1	6 + 00	202	Point No Point
2	18 + 00	205	Point No Point
3	30 + 00	208	Point No Point
4	42 + 00	211	Point No Point
5	54 + 90	214	Point No Point
6	68 + 10	217	Point No Point

5.2.3.3 Five, Equally-Spaced Sampling Interval Selection Scheme

The five, equally-spaced sampling interval selection scheme was used for sediment core boring locations where the 1940 horizon could be estimated from the bathymetric survey data but time-stratigraphic intervals could not be delineated due to the uncertainty in the bathymetric survey depths (as described in Section 8.0) being greater than the depth differences between these bathymetric surfaces. For this sampling scheme, one sample will be collected in the BAZ (i.e., from the present sediment surface to a depth of 0.5 feet) and five equally spaced homogenated samples will be collected to a depth corresponding to the estimated 1940 horizon. This scheme was only used if the 1940 sediment surface was predicted to be more than 5 feet below the present sediment surface. If less than 5 feet was predicted to be present, a 5 foot long core was collected as described in this section. The five, equally-spaced sampling interval selection scheme (designated "5-E" in Table 3-3 of the FSP) was used for the following 11 sediment core boring locations:

Transect Number	Project Station Designation	Sediment Core Boring Number	River Reach
7	82 + 10	220	Harrison
10	114 + 00	229	Harrison
11	126 + 00	232	Harrison
14	162 + 00	240	Harrison
15	174 + 00	243	Harrison
18	210 + 00	254	Newark
19	222 + 90	255	Newark
20	234 + 10	258	Newark
20	234 + 10	260	Newark
25	294 + 00	273	Kearny
26	306 + 00	278	Kearny

5.2.3.4 Five, One-Foot Sampling Interval Selection Scheme

The five, one-foot sampling interval selection scheme was used for sediment core boring locations where the 1940 horizon could be estimated from the bathymetric survey data but time-stratigraphic intervals could not be delineated, and the 1940 horizon was estimated to be less than 5 feet below the present sediment surface. This scheme was also used when the bathymetric data indicated an area of net scour or where all bathymetric survey depths were the same within the estimated uncertainty associated with those depths or where bathymetric data were not present. For this sampling scheme, one sample will be collected in the BAZ (i.e., from the present sediment surface to a depth of 0.5 feet) and five, one-foot long, homogenated samples will be collected to a depth of 5.5 feet below the present sediment surface. The five, one-foot sampling interval selection scheme (designated "5-1" in Table 3-3 of the FSP) was used for the following 31 sediment core boring locations:

Transect Number	Project Station Designation	Sediment Core Boring Number	River Reach
1	6 + 00	201	Point No Point
1	6 + 00	203	Point No Point
2	18 + 00	204	Point No Point
2	18 + 00	206	Point No Point
3	30 + 00	207	Point No Point
3	30 + 00	209	Point No Point
4	42 + 00	210	Point No Point
4	42 + 00	212	Point No Point
5	54 + 90	213	Point No Point
5	54 + 90	215	Point No Point
6	68 + 10	216	Point No Point
6	68 + 10	218	Point No Point
7	82 + 10	221	Harrison

Transect Number	Project Station Designation	Sediment Core Boring Number	River Reach
8	89 + 90	224	Harrison
9	102 + 00	227	Harrison
11	126 + 00	233	Harrison
13	150 + 00	237	Harrison
13	150 + 00	238	Harrison
15	174 + 00	244	Harrison
16	186 + 00	246	Newark
16	186 + 00	247	Newark
17	198 + 00	250	Newark
21	242 + 00	261	Newark
21	242 + 00	262	Newark
21	242 + 00	263	Newark
22	253 + 60	264	Newark
22	253 + 60	265	Newark
22	253 + 60	266	Newark
23	267 + 70	267	Kearny
23	267 + 70	268	Kearny
26	306 + 00	277	Kearny

5.2.4 Radiochemical Sample Depth Interval Selection

The sampling interval selection scheme for radiochemical analysis was based on interpretations of sedimentation rates derived from the historic bathymetry at each core location. Several strategies were employed for selecting the sampling intervals depending on the existence of useable bathymetry, the uncertainty of the sedimentation history based on the uncertainty in the associated bathymetry, and the dredge history at the given core location.

An average sedimentation rate for the core boring location was calculated from the bathymetric data for cores for which bathymetric data indicate that:

- sedimentation has occurred in a relatively continuous manner
- no dredging has occurred since 1949
- the distances between sediment surfaces derived from the bathymetric data are considered to be generally outside of the uncertainty in depth associated with those surfaces

Thirty core locations met the above criteria and for these cores, fourteen sampling intervals have been spaced evenly over the length of the core (1940 to present). This sampling interval is anticipated to provide a location of the ^{137}Cs, 1954 horizon with a precision of ± 2 years and to provide sufficient sampling points for the ^{210}Pb analyses to verify the sedimentation rates interpreted from the bathymetry. The cores marked CT for the chemical sampling interval selection scheme in FSP Table 3-3 represent the thirty cores planned for radiochemical dating using this sampling approach.

Sample intervals have been selected at a frequency designed to verify discontinuities or changes in sedimentation rate indicated by the bathymetry for the twenty-nine cores for which the dredging history or bathymetry indicate a discontinuity in sedimentation over time has occurred after 1949 or for which the bathymetric data indicate a major change in sedimentation rate. Between fourteen and nineteen sample intervals have been identified for these cores, with a higher frequency of sampling where uncertainty exists, and the remainder of the samples spaced over the rest of the core. Cores marked PT and 5-E on FSP Table 3-3 represent the twenty-nine cores for which this radiochemistry dating approach was used.

For the eleven of the 31 cores, designated 5-1 on Table 3-3 for which the bathymetric data indicate that a scouring condition exists or that the sedimentation rate is extremely slow (a predicted core length of two feet or less over the 1940 to present time period), cores 5.5 feet in length will be collected. For these eleven cores five evenly spaced radiochemistry sample intervals are planned. Absence of ^{137}Cs activity, and ^{210}Pb activities at natural occurring level, will be used to verify that the sediments were deposited prior to the 1940s.

For the eight cores of the 31 designated 5-1 on Table 3-3 in which the time stratigraphic intervals could not be delineated owing to sedimentation rates between bathymetric surfaces being within the uncertainty of those surfaces, but a 1940 sediment deposition horizon could be estimated from historic data, ten sampling intervals have been selected over the length of the core. For the twelve of the 31 cores that had no associated bathymetry in the Point No Point Reach, ten sampling intervals have been specified.

The radiochemical sample intervals selected by using the above strategies for the 78 cores to be collected under this IWP are presented in Table 3-4 of the FSP.

5.3 SELECTION OF ANALYTICAL SUITE

5.3.1 Chemical and Geotechnical Analyses

The selection of chemical analyses for core samples is based on the results of previous sediment analyses, all analyte classes specified to be analyzed in Section A.1 of the SOW, and all hazardous substances identified in Section IV of the AOC to be present at the Site. Geotechnical analyses are designed to provide sufficient physical characterization of the sediments for use in the hydraulic and sediment mobility modeling as well as evaluation of alternatives in the FS. Additional analyses to be conducted are total suspended sediment and bed load which will be used for sediment mobility modeling.

Table 5-2 summarizes the analytical program for core sediment samples collected at the Site. A complete list of analytes and analytical methods are tabulated in Section 3.0 of the QAPP for this RIWP. The location and selection of samples for analysis are described in Section 3.0 of the FSP.

5.3.2 Radiochemical Analyses

^{210}Pb, ^{137}Cs, and ^{7}Be activity will be measured in all cores collected within the Passaic River Study Area during the RI sampling event. These analyses will provide information for the interpretation of time stratigraphic intervals and sedimentation rates.

5.3.2.1 ^{210}Pb Radiodating

^{210}Pb radiodating is based on two major assumptions. First, it is assumed that atmospheric contributions of ^{210}Pb to sediments as they are being deposited are constant over time and, therefore, a decrease in the concentration of ^{210}Pb will occur in buried sediments related solely to its radioactive decay. Thus, the ^{210}Pb concentration in sediment should decrease exponentially as a function of time, since radioactive decay follows first order kinetics (the rate of decay is solely a function of the concentration of the ^{210}Pb present). The rate constant for ^{210}Pb decay is 3.11×10^{-2} years^{-1}. Second, it is assumed that the rate of sediment deposition at a given location is constant over time. Therefore, the sediment depth is assumed to be a linear function of time of deposition. A sedimentation rate can be calculated from the slope of the line obtained by plotting the ^{210}Pb concentration as a function of sediment depth.

A plot of the logarithm of the activity as a function of time should theoretically be a straight line with the slope of the line directly related to the rate of radioactive decay. A correction to the ^{210}Pb concentration is made for other natural contributions (background) from radioactive decay from elements for which it is a daughter product.

5.3.2.2 ^{137}Cs Radiodating

The ^{137}Cs radiodating technique that will be utilized on cores within the Passaic River Study Area is based on the premise that ^{137}Cs first was associated with sediments deposited in 1954 as a result of fallout from atmospheric testing of large nuclear weapons beginning that year. The sediment horizon associated with this date is interpreted as those sediments where ^{137}Cs is first detectable.

Additionally, in cores with continuous and relatively rapid sediment accumulation, the maximum levels of ^{137}Cs fallout can be associated with the years of peak fallout delivery of 1963 to 1964. However, the analytical uncertainty associated with identifying the point of maximum activity is greater than that for identifying the point of first measurable activity, making it difficult to assign the 1963 horizon to a specified depth. This is largely due to the fact that the onset of ^{137}Cs activity was a sharply defined event where activity increased greatly in 1954 related to the onset of above-ground nuclear tests. The 1963 maximum is a much less sharply defined event.

5.3.2.3 ^{7}Be Radiodating

^{7}Be is a natural fallout nuclide with a half-life of 53 days. This radionuclide produced by cosmic ray is present in both suspended matter and near-surface sediments if there has been recent deposition. Because of the short half-life, ^{7}Be is not expected to be detectable at depth. The ^{7}Be activity is reduced to 9 percent of its original value after six months, and is reduced to less than 1 percent after one year. The measurement of

^{7}Be activity in sediment cores will be used to determine whether there has been recent sedimentation and whether the near-surface portion of the core is intact after the sampling process.

5.4 USE OF RADIOCHEMISTRY TO COMPLEMENT BATHYMETRY

The FSP has been designed in accordance with the requirements of SOW Section 3.a.i.(4) which states that "All cores will be dated using the full range of radio-chemistry techniques, ^{210}Pb, ^{137}Cs, ^{7}Be. A description of how the radio-dating protocol will complement the proposed interval sampling and available bathymetry data will be included in the IWP along with a discussion of post analysis correlation". This section describes how the radiochemistry data will be used to complement the sampling interval selection which was based largely on historic bathymetric data and dredging history information, and provides a discussion of post analysis correlation.

As described in Section 5.2.3, sample intervals for chemical analyses have been selected for the 1940-1950, 1950-1960, 1960-1970, 1970-1980, 1980-BAZ, BAZ, and, 1955-1965 time periods. Four sample interval selection schemes were utilized based on the sedimentation history as delineated by historic bathymetry and the dredging history. The sampling interval selection process for radiochemical analysis of sediments in the 78 cores is described in Section 5.2.4. The sampling interval selection scheme for radiochemical analysis was based on the interpretations of sedimentation rate derived from the historic bathymetry and dredging history at each core location.

The data collected from the radiochemical analysis will undergo an uncertainty analysis which will include, but is not limited to:

- an assessment of the contribution to the overall uncertainty from counting statistics of all analyzed radionuclides

- regression analysis of the ^{210}Pb data points

- a residual analysis of the ^{210}Pb regression lines

- uncertainty analysis associated with the collection of ^{137}Cs samples within a core tube

Similarly, the bathymetry data has undergone an uncertainty analysis as described in Section 8.0 of this IWP.

The radiodating information will be used to evaluate whether the selected sample intervals are adequately representative of the time interval they are anticipated to represent. Verification that the sediment intervals sampled are representative of the time periods will be based on whether or not the radiodates are consistent with the core sampling intervals selected from bathymetry taking into account the calculated uncertainties.

^{210}Pb radiodating assumes that the sedimentation rate over the time interval being evaluated is constant, therefore, a large uncertainty is anticipated in the ^{210}Pb dates for a core with a highly variable sedimentation rate. Nonetheless, the ^{210}Pb data can be used in a qualitative manner to evaluate consistency with the sedimentation rates calculated from the bathymetry data. This will be done by normalizing the bathymetric sedimentation rates to the initial ^{210}Pb activity and then overlaying the ^{210}Pb data points over the activities predicted from the normalized sedimentation rates derived from historic bathymetry. Qualitative evaluation of consistency will be performed by comparison of measured activities to those predicted using the bathymetry data.